DOD Grant Number 18741

Alliance Monterey LLC

Final Project Description Report

December 20, 2004 – December 31, 2005

DoD FY03 Climate Change Fuel Cell Program

US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory

El Estero Wastewater Treatment Plant
City of Santa Barbara, California

February 28, 2006

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Abstract

A 500 kilowatt (KW) fuel cell cogeneration facility was installed at the City of Santa Barbara's El Estero Wastewater Treatment Plant (WWTP) in response to a competitive Request for Proposals. Prior to implementation of this project, anaerobic digester gas (ADG) produced by two (2) anaerobic digesters at the El Estero WWTP was burned in two boilers to generate hot water to heat the two anaerobic digesters at the site. Excess ADG not used in the boilers was burned in a flare at the site. To capture the value of the flared digester gas and improve overall energy efficiency at the El Estero WWTP, the City issued a Request for Proposals for bidders to provide a cogeneration system using ADG as a fuel.

Using ADG from the anaerobic digesters, the cogeneration facility produces electricity and thermal energy in the form of hot water that provides partial heating of the two anaerobic digesters at the WWTP. The ADG is first passed through a pretreatment skid to remove impurities that would adversely affect fuel cell operation. Electricity and thermal energy from the facility are sold to the City of Santa Barbara (City) through a long-term power purchase agreement (PPA) with Alliance Monterey LLC.

<u>Key topics</u>
At completion, the project represented the first and largest application of high-temperature molten carbonate fuel cell technology fueled by treated ADG at an unmanned facility in the United States.

Air permit requirements
Thermal recovery system challenges

Even operating at reduced output due to limited digester gas availability, total annual electric savings to the City from the fuel cell project are approximately $12,500. In addition, since the thermal energy from the fuel cells is provided at no additional cost to the City, annual savings assuming an existing boiler efficiency of 75% are slightly more than $25,000 per year at the City's average natural gas price of $10/MMbtu. Assuming full output, savings would increase to approximately $20,800 for avoided electricity purchases and $55,300 for thermal energy savings, or an annual total of about $76,000 per year.

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Executive Summary

Alliance Monterey LLC installed a cogeneration facility based upon two (2), 250-kilowatt (KW) rated DFC 300A fuel cell power plants manufactured by FuelCell Energy, Inc. (FCE) of Danbury, Connecticut. An anaerobic digester gas (ADG) pretreatment skid was installed as part of the project to clean and pressurize the ADG for use in the DFC 300A power plants. The fuel cell cogeneration facility can provide approximately 450 KW of electricity (net of ADG pretreatment skid parasitic electrical loads) for use at the WWTP, and operates in parallel with the local Southern California Edison (SCE) electrical grid. Exhaust heat from the two DFC 300A power plants is recovered through two (2) Cain hot water heat recovery units that are integrated into the digester heating system at the WWTP.

Energy savings have been lower than expected because of operation at reduced output levels due to lower than expected ADG fuel availability resulting from a City project to refurbish the two anaerobic digesters at the WWTP. One of the two anaerobic digesters at the WWTP site was out of service during the first year of the fuel cell operational period summarized in this report. As a result, the fuel cell power plants were operated at approximately 60 percent of full load output during the reporting period. Therefore, annual savings to the City were only approximately $37,500 during the first year of operation.

The point of contact for the City of Santa Barbara is:

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City of Santa Barbara
630 Garden Street
Santa Barbara, CA 93102
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1.0 Introduction

In March of 2004, Alliance Monterey LLC was selected by the City of Santa Barbara, California (City) through a competitive-bid process to install, own, and operate a fuel cell cogeneration system at the City's El Estero Wastewater Treatment Plant (WWTP) using anaerobic digester gas (ADG) as the primary fuel. Electrical and thermal energy from the cogeneration facility are sold to the City under a long-term energy purchase agreement. The project represents the largest application of molten carbonate fuel cell technology fueled by ADG at an unmanned facility in the United States.

2.0 Name, Address and Related Company Information

Alliance Monterey LLC
6 West Dry Creek Circle
Littleton, CO 80120
(303) 730-2328

Alliance Monterey LLC is a limited liability company formed by Alliance Power Inc. in 1999 to build, own, and operate distributed generation projects in California. In 2004, Alliance Monterey LLC entered into a long term power purchase agreement with the City of Santa Barbara to provide electricity and hot water from a fuel cell based cogeneration plant installed at the City's El Estero Wastewater Treatment Plant. This contract was a result of Alliance Power's successful response to Request for Proposal No. 4342 from the City of Santa Barbara to provide a cogeneration system using anaerobic digester gas (ADG) as the primary fuel. In return for construction and long term financing, in early 2004 Alliance Monterey LLC modified its membership to include FuelCell Energy Inc.

Alliance Power, Inc. is a developer of on-site cogeneration and distributed generation facilities serving municipal and industrial customers using innovative and environmentally-friendly technology.

3.0 Production Capability of the Manufacturer

FuelCell Energy, Inc. (FCE) is the leading high temperature stationary fuel cell manufacturer and developer of molten carbonate and solid oxide applications. FCE's patented Direct FuelCell (DFC) technology combines high efficiency, low emissions, simplicity and economical cost for stationary power generation. FCE's DFC products are quite simply the most efficient and cleanest means of generating electricity using natural gas and other renewable gaseous fuels.

The fuel cell units used in this project were two (2) 250KW DFC 300A molten carbonate fuel cell supplied by FCE from its Torrington, Connecticut manufacturing facility. FCE is a world leader in the development and manufacture of high temperature hydrogen fuel cells for clean electric power generation. FCE is a leading fuel cell technology developer for over 30 years with more than $450 million invested. FCE is headquartered in Danbury, CT with manufacturing facilities in Torrington, CT. FCE built its manufacturing operation with multiple purposes:

- Develop and refine the processes that will lead to large-scale manufacturing.
- Produce fuel cell components, stacks, and modules for commercial field trial by FCE and its partners.
- Produce fuel cells for FCE's ongoing R&D and improvement programs.

FCE's first manufacturing facility in Torrington, Connecticut began operations in 1992. On April 17, 2001 FCE unveiled a new 65,000 square foot manufacturing facility located in Torrington's Technology Park.

FCE contact: Rich Shaw
Marketing Director
3 Great Pasture Road
Danbury, Connecticut 06813-1305
Phone: 203-825-6015
Facsimile: 203-825-6079

FCE supplied the two DFC 300A fuel cell power plants, as well as technical direction during installation, commissioning services, and continuing maintenance services through a long-term service agreement with Alliance Monterey, LLC.

4.0 Principal Investigator(s)

Brian Moreau, Manager
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(303) 730-2518
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5.0 Host Facility Information

The host site for this project is the El Estero Wastewater Treatment Plant (WWTP) that is owned and operated by the City of Santa Barbara, California (City). The El Estero WWTP is located at 520 East Yanonali Street in Santa Barbara, California.

The El Estero WWTP provides secondary and advanced treatment of wastewater collected from the City of Santa Barbara. The WWTP was originally constructed in 1951 and has undergone several expansions to increase capacity to treat approximately 8.5 million gallons per day of domestic and industrial wastewater. Following treatment, effluent is discharged through an ocean outfall located approximately 1.5 miles off the coast. A portion of the effluent is subjected to additional treatment and distribution throughout the City's recycled water system.

The El Estero WWTP receives electricity from the Southern California Edison Company (SCE) and natural gas fuel from the Southern California Gas Company (Socal Gas).

6.0 Fuel Cell Installation

Prior to implementation of this project, ADG generated at the El Estero WWTP was burned in two 1.625 MMBTU/hour boilers to generate hot water to heat the two anaerobic digesters at the site used to treat and stabilize biosolids produced during the treatment of domestic wastewater. Excess ADG not used in the boilers was burned in a flare at the site.

Existing boilers in El Estero WWTP digester building

Fuel Cell Cogeneration site


Existing Flare Station

To capture the value of the flared digester gas and improve overall energy efficiency at the El Estero WWTP, the City issued a Request for Proposals on August 23, 2003 for bidders to provide a cogeneration system using ADG as a fuel. Following evaluation of several competitive proposals using conventional reciprocating engine technology, the City selected Alliance Monterey LLC in November, 2003 to install the fuel cell cogeneration system at the El Estero WWTP, and a long-term power purchase agreement (PPA) was executed between the parties on March 4, 2004. Under the PPA, Alliance Monterey LLC will own and operate the fuel cell cogeneration facility and sell the electricity and hot water to the City for a period of 12 years. The PPA provides for annual electricity sales at $0.085/kwh, with no charge to the City for recovered hot water. The combination of a fixed electricity price and no charge for thermal energy provides significant annual energy savings to the City, as compared with the otherwise applicable TOU-8 electricity rate from the Southern California Edison Company.

Historical monthly electrical usage at the El Estero WWTP during the 12 months prior to installation of the fuel cell cogeneration plant averaged about 608,000 kWh per month (see Section 12 for data). The fuel cell cogeneration plant is anticipated to replace approximately 50% of this electrical consumption currently purchased from the local electric utility.

In addition to the cost savings available under the power purchase agreement discussed above, the fuel cell cogeneration project results in significantly lower emissions compared to burning the ADG in the existing flare at the El Estero WWTP. The following table summarizes the emissions benefits to the City and local residents resulting from 2005 operation of the fuel cell project as compared to continued flaring of ADG:

Comparison - Emissions Reduction Delivered with Two FCE 250kW Power Plants Compared to Existing Flare			
Contaminant	Two DFC 300As (lbs/year)	Flare (lbs/year)	Expected Reduction (lbs/year)
Oxides of Nitrogen (NOx)	157	1,431	1,274
Oxides of Sulfur (SOx)	2	1,389	1,387
Carbon Monoxide (CO)	224	7,785	7,561
Volatile Organic Compounds (VOC)	45	1,199	1,154
Particulate Matter (PM)	--	425	425

The comparison is based on actual total 2005 ADG usage in the fuel cells of 35,245,762 standard cubic feet (scf), which is equivalent to 21,042 mmBTU at the average ADG BTU content of 597 BTU/scf. Total emissions from the flare are calculated using emissions factors from the existing air permit for the flare. Fuel cell emissions are calculated using emission factors developed by the California Air Resources Board (CARB) for certifying distributed generation resources. CARB issued Executive Order DG-003 on May 7, 2003 that certified that the DFC 300A fuel cell power plants comply with the 2007 distributed generation emissions standards.

The lower annual emissions shown above can be quantified financially using the emissions credit market in the Santa Barbara County Air Pollution Control District's territory. Based on recent Emissions Credit rates paid in Santa Barbara County, the emissions reductions delivered by the fuel cell cogeneration plant yield the following economic value to the City compared to continued flaring of excess ADG:

Economic Value of Emissions Reduction Using Historic SBCAPCD ERC Costs			
Contaminant	ERC Cost ($/ton)	Year	Value/year ($)
Oxides of Nitrogen (NOx)	35,000	2004	$22,295
Oxides of Sulfur (SOx)	8,750	2003	$6,068
Carbon Monoxide (CO)			
Volatile Organic Compounds (VOC)	37,500	2004	$21,638
Particulate Matter (PM)	7,500	2004	$1,594
Total Economic Value - Emissions Benefit			$51,595

The economic benefit from reduced emissions was calculated based upon actual 2005 operations, which was 60% of rated output due to lack of availability of adequate ADG fuel. Upon completion of the City's digester upgrade project, and restoration of normal fuel supply, the annual emissions savings would increase to approximately $86,000.

<u>Initial project activities</u>

The Alliance Monterey LLC proposal to the City was contingent upon receipt of grant funding from the FY2003 Department of Defense Climate Change Fuel Cell Program as well as the California Self-Generation Incentive Program (SGIP) administered by Southern California Edison. Alliance Monterey LLC applied to the DOD Climate Change Fuel Cell Program on June 1, 2004 and received approval for a project award of $500,000 on July 15, 2004.

Alliance Monterey LLC submitted an application to the SGIP program for grant funding for the project on December 1, 2003. The SGIP is an incentive program implemented by the California Public Utilities Commission (CPUC) that provides grant funds to promote and assist in the installation of cogeneration facilities on customer sites that offset new or existing electrical loads served by the utility. The project qualified for a Level 1 incentive payment of $4.50 per watt of generating capacity since it used fuel cell technology operating on a renewable fuel source (i.e., ADG). Alliance Monterey LLC received confirmation on May 5, 2004 that $2.25 million in grant funding would be provided from the SGIP upon successful completion of the project

The SGIP program recognizes the need for supplemental gaseous fuel for ADG applications and allows for natural gas usage up to 25% of the total annual energy input to facilitate stable cogeneration operations. A natural gas fuel supply was included in the project to serve as a supplemental or back-up fuel supply for those periods when ADG is not adequate to meet the fuel demands of the fuel cell cogeneration system or not available due to WWTP activities.

Permitting

FCE applied for and received a Distributed Generation (DG) Certification from the California Air Resources Board (CARB) in May 2003. CARB issued Executive Order DG-003 on May 7, 2003, which stated that the DFC 300A fuel cell power plant met all the CARB 2007 distributed generation emissions standards and therefore, should be exempt from permit requirements of air pollution control and air quality management districts as authorized under California Health and Safety Code section 41514.9.

Alliance Monterey LLC applied for an air permit exemption from the Santa Barbara County Air Pollution Control District (SBCAPCD) in December 2003 under SBCAPCD Rule 202.L.14, which exempts fuel cells from air permitting requirements as long as total emissions for the source are less than 10 tons per year. However, the CARB DG Certification for the DFC 300A fuel cell power plant was applicable to only natural gas fueled installations. The proposed project would utilize conditioned (i.e., treated) ADG. Since the CARB certification did not apply to conditioned ADG, the SBCAPCD required an air permit for the project that requires Alliance Monterey LLC to monitor the composition of the fuel entering the fuel cell power plants. The combined Authority to Construct and Permit to Operate No. 11215 for the project was issued by SBCAPCD on June 24, 2004.

The requirement to secure an air emission permit added time and cost to the project beyond what was anticipated. The City and the Air Pollution Control District were supportive of the project, and worked to expedite the permitting process in order to minimize any schedule impact.

City regulations required Alliance Monterey, LLC to file a Master Application with the City since the fuel cell cogeneration project involved construction of new facilities. The Master Application required approval from the following City departments prior to construction and operation of the cogeneration system:

- Architectural Review Board (ARB) – A landscaping proposal detailing where trees, bushes and plants would placed as a visual screen around the fuel cells at the El Estero WWTP was submitted to the ARB committee on March 9, 2004. The project received approval of the landscaping plan on March 29, 2004.

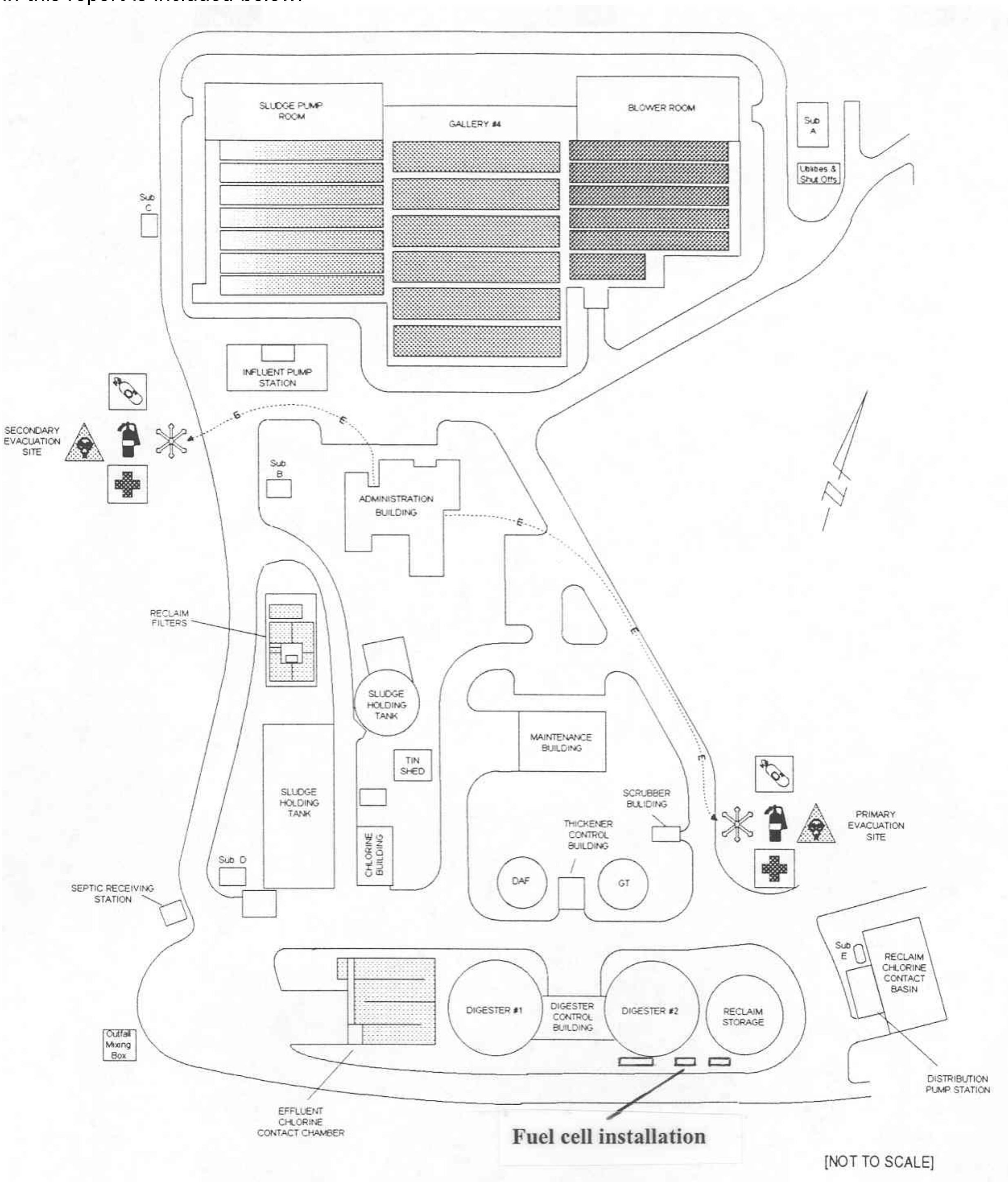
- California Coastal Commission – The El Estero WWTP is located within the jurisdiction of the California Coastal Commission. The cogeneration project qualified for an exclusion under the Coastal Act as a utility connection. The exclusion was granted by the City on March 18, 2004.

- Planning Division – The proposed fuel cell cogeneration project required a building permit prior to initiating construction. The building permit application process included submission of structural, electrical, and mechanical drawings for City review to verify project compliance with applicable City codes. The building permit for the project was issued on July 1, 2004.

Installation

The City's two (2) anaerobic digesters and ADG-fueled boilers are located along the south edge of the WWTP property. Two (2) 1.625 MMBTU/hr capacity boilers are located inside the Digester Control Building and produce hot water that provides heat to the anaerobic digesters to maintain the temperature inside the digesters at approximately 150 F. The existing ADG flare is located outside the Digester Control Building across a driveway on the south edge of the WWTP property. A railroad line and drainage channel are located immediately south of the WWTP property.

A site map showing the locations of the fuel cell installation and other plant facilities referenced in this report is included below.



The two fuel cells and associated equipment (digester gas pretreatment skid, hot water heat recovery units, electrical switchgear) were installed outside between the driveway and Digester No. 2 and the Reclaimed Water Tank.

The DFC 300A fuel cell power plants are factory tested prior to shipment and arrive ready for commissioning once the necessary field interconnections are completed. The digester gas pretreatment skid was similarly pre-assembled and delivered to the site. As a result, the majority of on-site construction activities consisted of completing interconnections between the major pieces of equipment and the existing infrastructure. Due to schedule issues, one of the two fuel cell power plants was shipped without the fuel cell module installed in order to expedite field interconnection work. FCE field services personnel installed the module on-site prior to the start of commissioning activities.

On-site construction activities began on July 5, 2004 with excavation for major equipment foundations and underground utilities (ADG fuel, natural gas, electrical, water, wastewater, and hot water loop piping). The following table summarizes the major construction activities and the date of completion:

Construction Activity	Completion Date
Construction Start	July 5, 2004
Excavation and Forming	August 17, 2004
Underground Piping	August 17, 2004
Foundations Poured	August 19, 2004
Fuel Cells Set	August 25, 2004
Fuel Pretreatment Skid Set	October 14, 2004
Interconnecting Piping Complete	October 19, 2004
Heat Recovery Equipment Set	September 29, 2004
Exhaust Ducting Complete	October 1, 2004
Electrical Tie-ins Complete	November 15, 2004
Fuel Gas Tie-in Complete	October 19, 2004
Certificate of Mechanical Completion	November 15, 2004
Provisional Performance Acceptance – BOP25	December 14, 2004
Provisional Performance Acceptance – BOP27	December 20, 2004
Final Performance Acceptance – BOP25	January 13, 2005
Final Performance Acceptance – BOP27	December 20, 2004

Construction activities on Fuel Cell #1 (DFC 300A Unit 25) and Fuel Cell #2 (DFC 300A Unit 27) were completed on November 14, 2004. Total man hours to complete the installation totaled approximately 3,920.

Excavation and Foundation Construction –July-August 2004

Foundation Construction – August 2004

Fuel Cell Placement – August 25, 2004

ADG Pre-Treatment Skid Installation – October, 2004

Heat Recovery Installation – October 2004

Site Interconnections

The digester gas pretreatment skid is located adjacent to the ADG line to the exiting flare station. This above-grade line was tapped to supply ADG for the pretreatment skid and the fuel cell power plants.

Existing Flare Line

Alliance Monterey LLC contracted for a new natural gas service from Socal Gas for the fuel cell cogeneration system. Socal Gas extended a new, 20 psig natural gas service line to the site from a supply line in a nearby street. The natural gas line connects to the ADG pretreatment skid prior to the final carbon canister to remove sulfur odorants from the natural gas prior to the fuel entering the fuel cells.

The DFC 300A fuel cell power plants produce electrical energy at 480 volts. The electrical balance of plant module on each fuel cell is connected by underground cable to the new 480-volt switchgear and metering cabinet located adjacent to Fuel Cell #1. The 480-volt switchgear is interconnected to the El Estero WWTP electrical system via buried cable to a spare 480-volt breaker in the existing switchgear in Substation D. The fuel cell cogeneration electrical system and interconnection to the El Estero WWTP and SCE electrical systems is further described in Section 7.

Potable water supply and wastewater discharge lines from the fuel cells connect to the existing systems at the El Estero WWTP at points within the Digester Control Building. The hot water loop piping for the two (2) hot water heat recovery units also interconnects with the existing system inside the Digester Control Building.

Commissioning
The DFC 300A power plants were set and interconnected with the necessary digester gas fuel, potable water, wastewater, and heat recovery connections, and were deemed mechanically complete by FCE on November 15, 2004. FCE field technicians commenced commissioning activities on the units on November 15th. Commissioning activities included setup of the on-board water treatment systems, calibration of fuel valves, and final electrical system checks. Commissioning was completed for Unit 25 on December 14, 2004 and on Unit 27 on December 20, 2004.

Total man hours expended during commissioning was approximately 730, including support from the construction contractor, and Alliance Power, Inc.

Operation
The rated output of 250 KW for each DFC 300A fuel cell power plant is net of parasitic electrical losses within the DFC 300A package, including water treatment system, enclosure ventilation, and inverter losses that total approximately 18 KW per DFC 300A. The cogeneration project included additional parasitic electrical loads associated with the ADG pretreatment skid. The ADG skid includes two (2) compressor/blowers and an electrical chiller. Also, a duplex hot water loop pump system was installed to circulate water through the fuel cell heat recovery system. These parasitic electrical loads total approximately 40 KW, thereby decreasing the net electrical output of the fuel cell cogeneration system to about 460 KW.

Current Operating Conditions
The two fuel cell power plants are currently operated at set points of approximately 180 and 190 KW. At this part load output setting, ADG fuel use is approximately 82 scfm. The reason for the reduced output is that the City undertook a digester renovation project beginning in January 2005 that has resulted in one of the two existing anaerobic digesters being out of service for the entire reporting period. As a result, digester gas production was less than optimal during this

period and operation of the fuel cells was limited to a maximum of 360 KW by a lack of adequate ADG fuel. While originally scheduled for completion in July 2005, the digester renovation project has encountered several delays that have extended the anticipated renovation period beyond the original schedule. The first of the two digesters to be renovated was placed back into service on February 24th, 2006. Digester improvements are scheduled to be complete by August, 2006.

While Alliance Monterey LLC could have used natural gas fuel during this period to operate at full output under the terms of the PPA, Alliance Monterey LLC did not pursue this option due to the extremely high natural gas prices that would have been passed onto the City.

7.0 Electrical System

The two, 250-KW DFC 300A fuel cell power plants at the El Estero WWTP are operated in parallel with the local SCE grid and are used as the primary power source for the site, with supplemental electricity purchases from SCE as necessary to meet total electrical demands. The fuel cells are electrically connected to the WWTP's 480V system at Motor Control Center (MCC) #5 in the Digester Control Building, which is ultimately connected to the SCE grid at the main electric meter for the site located in Substation A.

The CPUC issued an order in October 1999 instituting a new rulemaking procedure to address standardizing electrical interconnection standards. This rulemaking progressed into the rewriting of Rule 21, part of each investor-owned utility's tariff, which specifies standard interconnection, operating, and metering requirements for on-site generation facilities. The CPUC approved the Rule 21 language developed during the rulemaking on December 21, 2000.

The Rule 21 process standardizes the application process and the information to be provided for the utility to evaluate an interconnection request. Rule 21 also includes an equipment certification process whereby manufacturers submit technical information regarding the electrical protection capabilities of the equipment for review and approve by the IOUs. Technologies and equipment that satisfy the applicable utility protection requirements are certified as Rule 21 compliant, which streamlines the interconnection application process and field testing of the installed equipment.

A Rule 21 interconnection application was prepared and submitted to SCE on March 2, 2004 concurrent with the initial permitting and design activities. The DFC 300A electrical equipment is Rule 21 compliant, which simplified the interconnection process.

As part of the interconnection application, Alliance Monterey LLC had to designate whether excess power from the fuel cells would be exported from the site. Alliance Monterey LLC elected to obtain interconnection service from SCE under a net energy metering tariff (Schedule FC-NEM) for fuel cells. This tariff allows for export of power from the El Estero WWTP into the SCE grid. To achieve this net metering configuration, the City's main electric revenue meter was replaced with a bi-directional electricity meter to record electricity flow either into or out of the El Estero WWTP.

Southern California Edison required certain modifications to the existing interconnection relaying on site to allow power export from the site as long as the emergency generator was not running.

8.0 Thermal Recovery System

Prior to this project, two (2) ADG-fueled boilers provided the primary source of heating of the two anaerobic digesters. Average monthly heat supplied by the boilers is estimated to be 1,050 mmBTU per month. As part of this project, the existing ADG hot water system was extended to include the fuel cells heat recovery units (HRUs). The exhaust from each fuel cell unit is ducted to a Cain hot water HRU to capture the thermal energy in the exhaust. The recoverable thermal energy from each DFC 300A fuel cell power plant is approximately 0.3 mmBTU per hour (mmBTU/hr). Therefore, the fuel cell heat recovery system is designed to provide 0.6 mmBTU/hr (432 mmBTU per month) of thermal energy in the form of hot water.

A new below-grade hot water piping loop was interconnected to the existing hot water piping within the Digester Control Building and a new duplex pump system (70 gpm) added to circulate the hot water through the fuel cell HRUs. The hot water is used to heat the digesters to facilitate the anaerobic degradation of biological material which yields methane.

The fuel cell heat recovery system is designed for continuous operation to provide the primary source of heat for the digesters, supplemented by the two existing boilers. The fuel cell heat recovery system includes a radiator and fan to dissipate heat from the system in the event the fuel cell system is isolated from the WWTP hot water loop for any reason. This feature enables the fuel cells to continue full operation independent of the operation of the WWTP's heat recovery system.

The HRUs utilize a cross-flow configuration with the high temperature exhaust gas passing over coils through which the water flows. In this configuration, relatively cooler water enters the HRU near the gas exit and exits at the front of the HRU near where the hot exhaust from the fuel cell enters the HRU. In this configuration, the temperature difference between the gaseous exhaust and the water in the hot loop remains relatively constant across the length of the HRU, thereby maximizing heat transfer from the gaseous exhaust to the water. Water temperature across both HRUs and the radiator is measured through the use of multiple temperature sensors

The HRU piping was originally constructed using Schedule 80 CPVC plastic pipe and configured to enable either series or parallel operation of the two HRUs. However, City personnel noted a slow but continuous drop in water pressure in the hot water loop during fuel cell operation. An initial investigation discovered leaks in the underground CPVC joints, resulting in extensive repair work. Shortly after these repairs were completed, the problem recurred. Investigations to determine the source of the second instance of pressure loss ultimately led to the complete replacement of the plastic hot water pipe loop with black iron piping material in July 2005. Replacement of the fuel cell hot water piping loop (described in Section 13) eliminated the parallel configuration option. The two HRUs are now connected in series to incrementally increase the temperature of the hot water before it returns to the Digester Control Building.

The loss of proper flow in the hot water piping resulted in excessive loop temperatures in the heat recovery system, causing further damage. During replacement of the hot water piping loop, exhaust air bypass dampers were installed to shunt hot air around the Cain hot water HRUs in the event of high water temperatures.

Replacement of the hot water piping loop inadvertently resulted in co-current orientation through one of the HRUs. That is, low temperature water entered at front of HRU and exposed to highest exhaust gas temperature. This is a non-optimal configuration for heat recovery and decreased overall heat recovery for the system. Also as a result of this situation, water temperature measurements across this HRU are no longer accurate. This piping issue was corrected during a planned maintenance outage in February 2006.

9.0 Data Acquisition System

The DFC 300A fuel cell power plants are designed for unattended operation and are monitored remotely by FCE via an always on broadband connection to their control center located in Danbury Connecticut. Analog telephone lines serve as back-up communications in the event the internet service is interrupted. Fuel cell operating parameters such as fuel usage, power output, water consumption, etc., are monitored by each power plant, with data stored locally and uploaded to FCE on a daily basis.

The ADG pretreatment skid is equipped with an operator interface terminal that monitors power generation, total fuel utilization, and heat recovery system data. This data is stored locally, and can be uploaded to a remote user via broadband connection. The operator interface computer is equipped with a paging system that notifies the operator on duty in the event of an alarm on this subsystem. The operator is then able to log on to the system via a broadband or dial-up connection to determine the cause of the alarm, and initiate corrective actions.

10.0 Fuel Supply System

The fuel supply system for the fuel cells is designed for maximum flexibility. The fuel cell units can operate on both ADG and pipeline-quality natural gas supplies. ADG is the primary fuel with natural gas serving as alternative in case of interruption of ADG supply.

The ADG pretreatment skid installed as part of the project includes the following processing equipment:

- Inlet moisture separator (304 SS) with 5 micron mesh pad;
- Gardner Denver Cycloblower, or equal, designed to deliver 110 scfm at 16 psig (at the skid outlet). The blower will be equipped with an inlet and outlet silencer and sound attenuating enclosure. It will be equipped with a 25 hp TEFC motor;
- Digester gas to chilled water heat exchanger (304 SS) to lower digester gas temperature to 45º F;
- Ten ton chiller to supply chilled water;
- Digester gas to digester gas reheat heat exchanger (304 SS) to reheat cooled digester gas to about 80º F;
- Recycle line from reheat discharge to the inlet moisture separator to allow system to maintain a fixed discharge pressure (selected by operator) of 14 psig to 16 psig, at 0 to 100 percent flow, at the SCS skid outlet;
- Three-vessel gas polishing system consisting of a 2,000 lb first stage vessel filled with potassium permanganate impregnated activated carbon, a 4,000 lb second stage vessel filled with potassium permanganate impregnated zeolite media, and a 2,000 pound third stage filled with activated carbon (a guard stage). Sample taps will be provided to sample the discharge of each stage;
- Two, in parallel, 100 percent capacity one micron filters; and

- Instrumentation and control wiring, to provide a fully functional system, including inlet pressure transmitter and flow meter.

In addition to cleaning the ADG, the ADG pretreatment skid raises the ADG fuel supply pressure from approximately 8.6 inches water column to the 15-psig level required by the DFC 300A power plants.

In addition to the primary ADG fuel supply, Alliance Monterey LLC contracted with Socal Gas to install a new 20 psig natural gas supply for the fuel cell cogeneration project. The natural gas line connects to the ADG pretreatment skid prior to the final carbon canister to remove sulfur odorants from the natural gas prior to the fuel entering the fuel cells. Since all of the fuel is treated prior to entering the DFC 300A power plants, the carbon filtration systems included within the DFC 300A package were removed to minimize fuel gas pressure drop.

The original intent was to perform dynamic blending of natural gas and ADG fuels to enable full power operation even during times of reduced ADG availability. A combination of technical and economic concerns resulted in this option not being fully implemented. If ADG supply continues to be short during 2005, it is expected that this feature will be completed to enable the fuel cells to produce full rated output.

11.0 Program Costs

Construction Costs

Fuel Cell Equipment -$3,766,000
Installation – $1,091,694
Heat Recovery – Initial - $85,200
Heat Recovery - Exhaust bypass system – $17,794
Heat Recovery - Hot water piping replacement – $26,133

Performance Monitoring

Project Management during Construction – $233,422
Project Management during reporting period - $39,369

Fixed Operating Costs

Administration - $40,000
Insurance - $20,683
Fuel Cell Maintenance – $40,000 annual contract with FCE
Balance of Plant Maintenance costs - $19,200 annual contract with SCS Energy

Variable Operating Costs

Unscheduled Maintenance –$3,409 to SCS Energy for miscellaneous trouble calls
Telecom services - $3,600 - Verizon
Natural Gas – $7,398.96 for 6849 Therms while on hot standby (0 kW)
Anaerobic Digester Gas – Provided by El Estero at no charge, per PPA

Local gas and electricity prices

The local natural gas cost for the usage purchased by the City averaged approximately $10/mmBTU based on available Socal gas bills. Natural gas charges increased from less than $8/mmBTU to over $12/mmBTU over the course of the year.

Average electricity cost from the utility in 2005 was approximately $0.09/kWh based on SCE bills. The City purchased electricity from the fuel cells at a contracted rate of $0.085/kWh, which yields an annual savings of 5.6% on the electricity from the fuel cells versus what would have otherwise been purchased from the local utility. In 2006, SCE expects a 30% rate increase, which, if combined with full power operation upon completion of the digester upgrade project, should result in significant costs savings to the City.

12.0 Operational Data and Results

Instrumentation on each DFC 300A power plant records data for a variety of parameters. These measurements are compiled and stored in the Human Machine Interface (HMI) on each DFC 300A unit, and uploaded to FCE remote servers on a daily basis for long term storage. Similarly, data from the ADG pretreatment process is recorded and stored on the ADG skid HMI. In addition to this on-board instrumentation, several temperature sensors were installed to monitor water temperatures at various points in the fuel cell heat recovery system. Data from these sensors are also recorded on the ADG skid HMI.

The following table summarizes the source of the requested data and the derivation of the values presented in the data tables below.

Parameter	Data Source	Derivation of Value
Rated Fuel Cell Capacity (kW)	FCE Literature	NA
Total Operating Hours (hrs)	DFC 300A HMI	Sum of values recorded during data period
Total Time in Period (hrs)		Calculated based on defined data period
Availability (%)	Calculated value	Total Operating Hours / Total Time in Period
Total Energy Produced (kWh)	DFC 300A HMI and AM LLC revenue meter	Total value over data period net of internal DFC 300A parasitic electrical losses
Average Electric Output (kW)	DFC 300A HMI and AM LLC revenue meter	Average of values recorded during data period net of internal DFC 300A parasitic electrical losses
Peak Electric Output (kW)	DFC 300A HMI and AM LLC revenue meter	Highest of values recorded during data period net of internal DFC 300A parasitic electrical losses
Capacity Factor (%)	Calculated value	Total Energy Produced / (Rated Fuel Cell Capacity x Total Time in Period)
Fuel Usage (BTU)	DFC 300A HMI	Calculated using average fuel flow in standard cubic feet (measured by on-board instruments) during data period multiplied by average of four (4) quarterly heat content analyses (average = 597 BTU/scf)
Heat Recovery Rate (BTU/hr) (1)	Calculated value using monthly average data	70 gpm x 8.34 lb/gal x (T2-T1) x 60; where T2 is water temperature exiting HRUs and T1 is water temperature entering HRUs
Heat Rate (BTU/kWh)	Calculated value	Fuel Usage / Total Energy Produced
Electrical Efficiency (%)	Calculated value	Total Energy Produced x 3413 / Fuel Usage
Thermal Efficiency (%)	Calculated value	Heat Recovery Rate / Thermal Energy in Fuel Cell Exhaust (estimated at 70% output rating)
Total Thermal Heat Recovery (BTU) (1)	Calculated value	Sum of monthly values from March 2005 to December 2005

(1) Calculated using data from March 2005 through December 2005.

Following completion of a Final Performance Acceptance test, Fuel Cell #1 (FCE Unit 25) began commercial operations on December 20, 2004. Similarly, Fuel Cell #2 (FCE Unit 27) started commercial operations on January 13, 2005. Therefore, the data shown in the following tables for Fuel Cell #1 (FCE Unit 25) are from December 20, 2004 to December 31, 2005, and the values shown for Fuel Cell #2 (FCE Unit 27) are from January 13, 2005 to December 31, 2005.

Fuel Cell Operating Data - Unit 25 (1/13/05 - 12/31/05)

Rated Fuel Cell Capacity	250	kW	Fuel Usage (LHV)	10,645	mmBtus
Total Operating Hours	6,887	hrs	Thermal Heat Recovery	885	mmBtus
Total Time in Period	8,459	hrs	Heat Recovery Rate	167,623	Btus/hr
Availability	81	%	Heat Rate	9,403	Btus/kWh
Total Energy Produced	1,132,077	kWe-hrs	Electrical Efficiency	36.3	%
Average Electric Output	164	kW	Thermal Efficiency	44.9	%
Peak Electric Output	258	kW	Total Thermal Heat Recovery	885,000,000	Btus
Capacity Factor	56	%			

Fuel Cell Operating Data - Unit 27 (12/20/04 - 12/31/05)

Rated Fuel Cell Capacity	250	kW	Fuel Usage (LHV)	10,712	mmBtus
Total Operating Hours	6,939	hrs	Thermal Heat Recovery	1,040	mmBtus
Total Time in Period	9,048	hrs	Heat Recovery Rate	173,053	Btus/hr
Availability	76	%	Heat Rate	9,335	Btus/kWh
Total Energy Produced	1,147,500	kWe-hrs	Electrical Efficiency	36.4	%
Average Electric Output	165	kW	Thermal Efficiency	46.3	%
Peak Electric Output	266	kW	Total Thermal Heat Recovery	1,040,000,000	Btus
Capacity Factor	53	%			

The values for Availability and Capacity Factor in the previous two tables were adversely impacted by two circumstances. First, as further described later in this Section, an extended outage occurred at the site from July 13, 2005 to August 17, 2005 due to a City contractor damaging the ADG fuel gas supply piping to the cogeneration system. As a result, both fuel cell units were off-line for over 35 days. During this time, the fuel cells operated in standby mode on natural gas fuel. Full electrical production using natural gas was not pursued due to potential cost impacts on the City. Without this unplanned, third-party outage, the availability values for Unit 25 and Unit 27 would be 90 and 85 percent, respectively.

In addition to the impact of this extended outage, the Capacity Factor values presented above were also affected by a limited supply of ADG fuel as a result of the City's digester renovation project. After numerous alarms and shutdowns of the ADG pretreatment skid because of lack of inlet ADG fuel pressure, the output settings on both fuel cells were reduced to approximately 180 KW on December 5 to maintain stable operation of the entire cogeneration system. Over the course of the reporting period, including sustained outages due to loss of ADG and repairs to the heat recovery system, the two fuel cell units operated at an average output of approximately 60%. When called upon to operate, and provided with fuel, the fuel cells performed as expected.

Thermal Heat Recovery

Data for the heat recovery systems shown in the tables above are limited due to several issues. First, data during the early months of operation (January and February) are not available due to problems with the newly-installed hot water piping. Water pressure within the hot water loop decreased continually after the fuel cell units were brought on-line, indicating a leak in the system. Efforts to locate the leak were difficult since the hot water piping was below grade. The entire piping run had to be excavated to locate and repair the leaks. During this time, the HRUs were bypassed so that the City system could continue to operate.

Initial repairs of leaks in the hot water loop did not provide a reliable solution. The existing below grade Schedule 80 CPVC piping was replaced with black iron piping to provide a more robust installation. Unfortunately, the new piping between the two HRUs was installed incorrectly, with the water flowing into the outlet of the second HRU and exiting on the inlet side. As a result, the incorrect orientation of the hot water piping prevented the existing temperature sensors from being able to monitor heat recovery across the second HRU. Therefore, heat recovery values for Unit #1 after June were estimated by subtraction of Unit #2 heat recovery from the total heat recovery for the system.

Net Cogeneration System Output

Data presented in the previous two tables were derived from information obtained from the DFC 300A fuel cell power plants. As such, the values do not include the impact of electrical parasitic losses associated with the ADG pretreatment skid or the heat recovery system. A new electric revenue meter installed as part of the project records electricity delivered and billed to the City under the PPA, which is net of all parasitic losses.

The following table shows the total annual electricity delivered to the WWTP by the fuel cell cogeneration system. The table compares the total annual electricity delivered to the WWTP to the total electricity produced by the fuel cells to determine the parasitic electrical losses associated with the ADG pretreatment skid and heat recovery system. The table also calculates the impact of these parasitic losses to show the overall system performance. Note that the values presented are for part load operation of approximately 65% full load output.

		Unit 25	Unit 27	Total
Total electricity revenue billing to WWTP	kWh			2,060,800
Total ADG skid parasitic losses	kWh	90,496.9	88,554.2	179,051.0
(based on ratio of net fuel cell output)				
Average ADG skid parasitic demand	KW	13.1	13.2	26.4
Net plant output	kWh	1,041,580	1,019,220	2,060,800
Average net plant output	KW	151.2	152.5	303.7
Fuel Usage - HHV	scf	17,830,534	17,415,229	35,245,762
Average BTU/scf		597	597	
Fuel Usage - HHV	mmBTU	10,645	10,397	21,042
Net Heat Rate - fuel cells	BTU/kWh	9,403	9,385	9,394
Net Heat Rate - plant	BTU/kWh	10,220	10,201	10,210
Net Electrical Efficiency - fuel cells	%	36.3%	36.4%	36.3%
Net Electrical Efficiency - plant	%	33.4%	33.5%	33.4%

Changes in Site Energy Use

Electrical usage data presented in the following two tables were obtained from monthly City electrical bills from SCE. Monthly site fuel usage data was obtained from monthly natural gas bills from Socal Gas and daily ADG production and consumption logs from the City. Peak daily gas usage figures are not available.

Site Parameters Prior to Fuel Cell Installation				
Month	**Total Monthly Site Electrical Usage kWe-hrs**	**Peak Site Electrical Usage kW**	**Total Monthly Site Fuel Usage (HHV) MMBtu**	**Peak Site Fuel Usage (LHV) MMBtu/day**
Dec-03	568,080	960	1,318	NA
Jan-04	561,168	960	1,504	NA
Feb-04	635,232	1,248	1,555	NA
Mar-04	578,280	1,056	1,249	NA
Apr-04	582,288	960	1,456	NA
May-04	663,024	1,056	893	NA
Jun-04	596,640	1,056	897	NA
Jul-04	595,416	1,056	914	NA
Aug-04	654,312	1,056	575	NA
Sep-04	657,080	1,152	617	NA
Oct-04	600,432	1,056	900	NA
Nov-04	611,640	1,152	1,150	NA

Site Parameters During Fuel Cell Installation				
Month	Total Monthly Site Electrical Usage kWe-hrs	Peak Site Electrical Usage kW	Total Monthly Site Fuel Usage (LHV) MMBtu	Peak Site Fuel Usage (LHV) MMBtu/day
Dec-04	490,104	1,248	1394	NA
Jan-05	359,376	1,056	1018	NA
Feb-05	349,968	960	765	NA
Mar-05	306,264	1,056	262	NA
Apr-05	408,888	1,152	429	NA
May-05	365,616	1,056	65	NA
Jun-05	425,424	1,056	230	NA
Jul-05	515,050 (est.)	NA	207	NA
Aug-05	451,416	1,152	40	NA
Sep-05	441,792	1,056	48	NA
Oct-05	366,984	960	64	NA
Nov-05	396,408	960	221	NA

Energy Usage Reduction

Comparison of the two tables reveal that average monthly electrical energy usage at the El Estero WWTP was 608,633 kWh per month for the 12 month period from December 2003 to November 2004. Following commercial operation of the fuel cell cogeneration system in December 2004 (Unit #1) and January 2005 (Unit #2), the average monthly electrical energy usage decreased to 406,411 kWh per month for the 12 months from December 2004 to November 2005.

Based on revenue meter data, the fuel cells reduced average monthly electrical energy consumption by approximately 171,700 kWh per month, or a little more than 2,060,000 kWh per year, which is equivalent to a 28% reduction in electrical usage. The total reduction in annual energy usage at the El Estero WWTP following start-up of the fuel cell cogeneration system, as indicated by monthly SCE electric bills, was 2,426,300 kWh. Eighty-five percent (85%) of this reduction was attributable to the fuel cells. The remaining reduction in electrical consumption at the site was likely related to changes in WWTP operations, including the digester modification project.

Based on PPA contract and applicable SCE electric rates, total annual electric savings to the City from the fuel cell project are approximately $12,500. In addition, since the thermal energy from the fuel cells is provided at no additional cost to the City, annual savings assuming an existing boiler efficiency of 75% are slightly more than $25,000 per year at the City's average natural gas price of $10/MMbtu. Assuming full output, savings would increase to approximately $20,800 for avoided electricity purchases and $55,300 for thermal energy savings, for a total annual savings of about $76,000 per year.

Demand Reduction

A comparison of the peak site electrical usage (i.e., demand) before and after initiation of the fuel cell cogeneration plant does not show a reduction in electrical demand that would be expected from operation of the 500 KW fuel cell cogeneration system. The reason for this apparent discrepancy is not related to the operation of the fuel cells, but rather to City procedures associated with monthly testing of an on-site emergency engine generator.

A two (2) MW emergency diesel generator is located at the El Estero WWTP in order to provide electrical power in the event of an interruption from the SCE utility grid. The City performs a monthly test of the emergency generator and transfer switch to verify operation, and the test procedure takes approximately 2 hours. During the test, the City manually operates the main utility breaker to simulate a grid outage, which exercises the transfer switch and starts the emergency generator. The generator then ramps up to pick up the plant load. Once the test is completed, the generator is shut down, the main utility breaker is closed, and the fuel cell will re-synchronize with the grid and ramp back up at a rate of 1/2kW per minute.

As described in Section 7, the fuel cell cogeneration system cannot operate in the absence of the SCE grid. Therefore, since the main SCE electric meter records electrical usage and demand at the El Estero WWTP every 15 minutes, when the grid interconnection is re-established after the generator test, the plant load establishes the monthly peak demand before the fuel cell can ramp up to full power to provide an offset.

In the absence of this generator testing procedure, the El Estero WWTP should see a demand reduction equal to the net output of the fuel cell cogeneration facility, approximately 450kW per month.

Thermal Energy Usage Reduction

Total thermal energy consumed on site as determined by the sum of natural gas and ADG boiler usage decreased significantly following initiation of fuel cell operations. Based on records of ADG boiler usage and natural gas bills from Socal Gas, average monthly thermal energy usage at the El Estero WWTP was 1086 MMBtu per month for the 12 month period from December 2003 to November 2004. Following commercial operation of the fuel cell cogeneration system, the average monthly thermal energy usage decreased to 395 MMBtu per month for the 12 months from December 2004 to November 2005, or 36% of the previous years thermal energy demand. Only a portion of this decrease was attributable to the fuel cells, which provided an estimated 120 MMBtu per month of thermal energy from March through November. The ongoing digester modifications likely significantly reduced the thermal energy demand at the site.

Outages

Three types of outages were catalogued by the fuel cell HMIs during operation of the fuel cell cogeneration system: planned fuel cell equipment outages, forced fuel cell equipment outages, and third-party outages caused by events or equipment other than the DFC 300A fuel cell power plants. The following tables show the Scheduled and Unscheduled Outages for each fuel cell power plant including and excluding outages attributable to the third-party events. Separating the outages in this manner enables a better understanding of the reliability performance of the DFC 300A power plants themselves. However, it is important to recognize that the increased outages associated with third-party outages increased the ability of FCE to perform routine checks that might otherwise have required an outage.

Fuel Cell Outages - Unit 25		
	With 3rd party outages	Without 3rd party outages
Mean Time Between Failure	162 hrs	544 hrs
Total Scheduled Outages	3	3
Mean Time of Scheduled Outages	2.8 hrs	2.8 hrs
Total Unscheduled Outages	39	11
Mean Time of Unscheduled Outages	38.6 hrs	26.7 hrs

Fuel Cell Outages - Unit 27		
	With 3rd party outages	Without 3rd party outages
Mean Time Between Failure	127 hrs	492 hrs
Total Scheduled Outages	1	1
Mean Time of Scheduled Outages	2.2 hrs	2.2 hrs
Total Unscheduled Outages	52	15
Mean Time of Unscheduled Outages	38.5 hrs	44.9 hrs

The most common cause of third-party outages was the restriction or interruption of the ADG fuel supply to the fuel cells. In addition, electrical grid disturbances caused the fuel cells to trip off-line several times during the operating period. The Digester Gas Pretreatment Skid frequently tripped off-line due to low ADG suction pressure as a result of overdrawing of the available ADG supply, particularly during daily sludge dewatering activities at the WWTP when sludge is withdrawn from the digesters. Loss of the ADG skid then caused the fuel cells to trip off-line, due to loss of fuel. This issue was addressed by modifying the output control logic on the fuel cells to reduce output if the ADG supply pressure decreased substantially, thereby reducing fuel demand and providing time for the ADG supply to stabilize and recover.

The most common cause of outages attributable to the DFC 300A fuel cells themselves was control logic issues that required modifications to the control software. Complete Down Time Reports for Units 25 and 27 are included in the Appendix.

13.0 Milestones/Improvements/Lessons Learned

Milestone achievements

The El Estero WWTP fuel cell cogeneration facility was the first unmanned molten carbonate fuel cell installation designed to run on 100% ADG fuel. The design had to accommodate multiple fuel cells, each operating between hot-standby and full load, and had to be able to automatically respond to a variety of conditions including loss of utility grid, fluctuating ADG availability, unplanned trip of one fuel cell, and unplanned outage of the ADG pretreatment skid. Through the course of the design, and first year of operations, success was achieved as measured by the high availability realized.

Modifications and Improvements

Fuel cell internal fuel piping was modified to accommodate the higher volume of fuel required due to low BTU content of ADG. Fuel cell control system optimized for remote operations, providing an automated method to conserve ADG fuel by performing a two step load reduction in response to low and low-low ADG supply pressure.

Modified controls on ADG pretreatment skid to automatically switch from ADG to natural gas and back in response to fluctuating fuel supply. Modified ADG pretreatment skid to provide separate fuel trains to each fuel cell to enable one unit to operate on NG while the other is operating on ADG.

The original design of the thermal recovery system was based upon City personnel operating the system, and provided maximum flexibility through selectable series or parallel operating modes. During construction and early operations, it was determined that unmanned operation was preferred by the host site. Hot water piping originally consisted of CPVC due to superior thermal performance compared to insulated iron pipe. Early problems with the piping system included below grade leaks in the CPVC piping due to poor quality installation, and over temperature operation due to operator error.

In order to prevent over temperature operating modes, an automatic exhaust gas bypass damper was field installed on each Cain HRU to maintain water loop temperature within operating limits an near zero water flow. To prove a more robust installation that would better tolerate unmanned operation, the below grade CPVC piping was replaced with insulated black iron piping, and the series/parallel operating mode was replaced with a non-selectable series operating mode. These modifications to the heat recovery system were completed in by the third quarter of 2005, and appear to have successfully addressed problems discovered in the original installation.

A modification planned for 2006 is the addition of a rapid load recovery feature in the FCE control program that will greatly improve the power ramp rate for outages caused by momentary trips of the utility's electric grid.

Lessons Learned

The standard water treatment system provided by FuelCell Energy is designed for a particular input water quality. It was found that the site's potable water quality was outside of FCE specifications, which required a late modification to the FCE water treatment system. Early testing of the site's available water supply is an important step to be performed early in the planning stages by the project implementation team. Early detection of water quality issues would enable a factory designed solution, as opposed to field solutions developed by the construction team.

The existing boiler system and hot water loop at El Estero WWTP provided integration challenges to the design team. Most of the lessons learned on the heat recovery system deal with minimizing operational and maintenance requirements, especially important for projects of this type where the host customer does not own the fuel cell cogeneration facility. In addition to a more robust piping installation, exhaust bypass dampers, and fixed operating mode (series), a feature to be considered on future projects would be the addition of a secondary heat exchanger to isolate the host customer's hot water loop from the cogeneration system hot water loop.

For installations similar to El Estero WWTP, where fuel cell ADG requirements are greater than 80% of site production, a secondary fuel source is mandatory due to typical fluctuations that occur at anaerobic digester gas production facilities. Events that illustrate this fluctuation include a digester outage event, heavy, prolonged rains that reduced the BTU content of the ADG, and normal plant operations (dewatering press).

An analysis of fixed operating costs has identified telecommunications charges as a target for possible cost reduction efforts. Alliance Monterey, LLC has asked FCE to investigate moving paging requirements off of dedicated dial-up circuits and onto a shared broadband connection to reduce fixed O&M costs.

14.0 Conclusions/Summary

In March of 2004, Alliance Monterey LLC was selected by the City of Santa Barbara, California (City) through a competitive-bid process to install, own, and operate a fuel cell cogeneration system at the City's El Estero Wastewater Treatment Plant (WWTP) using anaerobic digester gas (ADG) as the primary fuel. Electrical and thermal energy from the cogeneration facility are sold to the City under a long-term energy purchase agreement. The project represents the largest unmanned facility employing molten carbonate fuel cell technology fueled by ADG in the United States.

The installed cogeneration facility is based upon two (2), 250-kilowatt (KW) rated DFC 300A fuel cell power plants manufactured by FuelCell Energy, Inc. (FCE) of Danbury, Connecticut. An anaerobic digester gas (ADG) pretreatment skid was installed to clean and pressurize the ADG for use in the DFC 300A power plants. The fuel cell cogeneration facility can provide approximately 450 KW of electricity (net of ADG pretreatment skid parasitic electrical loads) for use at the WWTP, and operates in parallel with the local Southern California Edison (SCE) electrical grid. Exhaust heat from the two DFC 300A power plants is recovered through two (2) Cain hot water heat recovery units that are integrated into the digester heating system at the WWTP.

The facility had a first year availability factor of 85-90%, neglecting third party outages. Capacity was 60% of expected due to frequency of third party outages and reduced availability of ADG fuel supply. Capacity performance is expected to improve during 2006, with maximum capacity being achieved upon completion of the El Estero WWTP digester refurbishment project.

The total installed cost of the project was $5,167,000 which was offset by a rebate of $2,250,000 from the Self Generation Incentive Program and a grant of $500,000 from the DOD Climate Change Fuel Cell Program. The final net cost of the project was $2,417,000 or $4,834/kW of generating capacity.

Appendix - Down Time Reports

ID #	DateTimeDown	DateTimePower	TBF	PlanCodeStatus	Major_Component	Category	SubCat	Duration
	31-Dec-05							
1	23-Dec-05	25-Dec-05	154	Customer	Controls System (ELEC)	Hardware(Elec)		49.0
2	30-Nov-05	30-Nov-05	549	Forced	Controls System (I&C)	Software (I&C)	Versapro	2.8
3	02-Nov-05	02-Nov-05	671	Customer	External Influence	Customer Equipment	N/A	8.0
4	21-Oct-05	23-Oct-05	236	Forced	Controls System (I&C)	Hardware(I&C)	Communications	54.3
5	16-Oct-05	16-Oct-05	114	Forced	Fresh Air Group	Electrical	Inoperable	4.0
6	05-Oct-05	11-Oct-05	116	Forced	Controls System (I&C)	Software (I&C)	Versapro	150.5
7	03-Oct-05	04-Oct-05	5	Customer	External Influence	Customer Equipment		42.2
8	11-Sep-05	11-Sep-05	514	Planned	Water Treatment Group	Other	Other	4.3
9	07-Sep-05	07-Sep-05	92	Forced	RECYCLE GROUP	Mechanical	Deteriorated/Worn	12.2
10	31-Aug-05	31-Aug-05	160	Forced	Fresh Air Group	Instrumentation	Out of Calibration	2.0
11	27-Aug-05	27-Aug-05	89	Forced	Fresh Air Group	Instrumentation	Out of Calibration	2.0
12	20-Aug-05	21-Aug-05	160	Forced	Controls System (ELEC)	Hardware(Elec)	Drives	10.0
13	13-Jul-05	17-Aug-05	74	Customer	External Influence	Customer Equipment	N/A	844.0
14	28-Jun-05	28-Jun-05	355	Customer	External Influence	Customer Equipment	N/A	1.8
15	28-Jun-05	28-Jun-05	2	Customer	External Influence	Customer Equipment	N/A	2.5
16	20-Jun-05	21-Jun-05	161	Customer	External Influence	Customer Equipment	N/A	28.3
17	17-Jun-05	17-Jun-05	71	Customer	External Influence	Customer Equipment	n/a	2.5
18	08-Jun-05	08-Jun-05	202	Forced	Water Treatment Group	Personnel/Procedure	Operator error	7.5
19	01-Jun-05	01-Jun-05	165	Customer	External Influence	Customer Equipment	N/A	9.8
20	04-May-05	04-May-05	669	Customer	External Influence	Customer Equipment	na	5.7
21	30-Apr-05	01-May-05	66	Customer	External Influence	Fuel Gas	External Equipment	22.2
22	30-Apr-05	30-Apr-05	2	Customer	External Influence	Fuel Gas	External Equipment	5.5
23	28-Apr-05	29-Apr-05	20	Forced	External Influence	Human Performance Error	Operator Error	33.3
24	22-Apr-05	23-Apr-05	112	Customer	Controls System (ELEC)	Software(Elec)	Drives	10.3
25	18-Apr-05	19-Apr-05	96	Customer	External Influence	Human Performance Error	FCE technician error	1.5
26	13-Apr-05	13-Apr-05	127	Forced	Electrical Panels Group	Electrical	Overheated/Burned	14.7
27	05-Apr-05	05-Apr-05	175	Customer	Controls System (I&C)	Software (I&C)	Cimplicity	11.2
28	17-Mar-05	17-Mar-05	453	Planned	Controls System (I&C)	Software (I&C)	Versapro	1.7
29	28-Feb-05	02-Mar-05	355	Customer	Controls System (I&C)	Software (I&C)	Versapro	40.8
30	26-Feb-05	27-Feb-05	26	Customer	Controls System (I&C)	Software (I&C)	Versapro	28.3
31	18-Feb-05	18-Feb-05	195	Customer	Controls System (I&C)	Software (I&C)	Versapro	2.3
32	16-Feb-05	16-Feb-05	41	Planned	Controls System (I&C)	Software (I&C)	Versapro	2.5
33	16-Feb-05	16-Feb-05	2	Customer	External Influence	Series of Test	Logic	4.5
34	15-Feb-05	16-Feb-05	0	Customer	External Influence	Fuel Gas	Supply interruption	7.7
35	15-Feb-05	15-Feb-05	1	Customer	External Influence	Fuel Gas	Supply interruption	2.0
36	15-Feb-05	15-Feb-05	0	Customer	External Influence	Fuel Gas	Supply interruption	4.0
37	13-Feb-05	15-Feb-05	0	Customer	External Influence	Fuel Gas	Supply interruption	42.5
38	13-Feb-05	13-Feb-05	2	Customer	External Influence	Fuel Gas	Supply interruption	3.5
39	08-Feb-05	08-Feb-05	123	Customer	External Influence	Fuel Gas	Pressure Deviation	1.7
40	03-Feb-05	03-Feb-05	113	Customer	External Influence	Fuel Gas	Fuel Deviation	3.0
41	01-Feb-05	01-Feb-05	52	Customer	External Influence	Protection Failure	Grid Disturbance	4.5
42	25-Jan-05	25-Jan-05	151	Customer	External Influence	Fuel Gas	Supply interruption	21.8
		13-Jan-05	277				**total**	**1512.9**
		total time between failure	6946					

			Number of events
Mean Time Between Failure	162	hrs	
Total Scheduled Outages	8.5	hrs	3
Mean Time of Scheduled Outages	2.8	hrs	
Total Unscheduled Outages - Fuel Cell	293.3	hrs	11
Mean Time of Unsched. Outages - Fuel Cell	26.7	hrs	
Total Unscheduled Outages - Customer	1211.1	hrs	28
Mean Time of Unsched. Outages - Customer	43.3	hrs	

total outage	1512.9
total hours	8459

ID #	Issue
1	Plant ESD'd at 0400 on a grid disturbance. Power could not be restored for several hours. UPS lost power prior to restart.
2	On an alarm kW ramp, the unit ramped to 82.1 kW vice 100 kW. Now the plant will not ramp up until ADG suction pressure goes up.
3	Plant taken to HSBY for emergency diesel generator testing
4	A F60 to PLC communication failure alarm caused the plant to trip to HSBY. Two minutes later, the PCU to PLC communication failure alarm came in. After several minutes the alarm conditions cleared.
5	During a trip to IHSBY mode, the fresh air blower control caused a FRALL0417 condition that caused the plant to ESD. This problem is documented on another turnback, this is to record the ESD.
6	When plant goes to HSBY KVAR mode appears to be enabling itself. Found KVAR enabled twice on the plant. Request I &C evaluate logic.
7	ADG Skid Chiller Failure. SCS rep unable to find cause. Troubleshoot for the day and later was able to correct fault.
8	Operator initiated trip to HSBY at 3pm to conserve water due to prolonged water system maintenance.
9	ESD due to UA0406_F (recycle blower failure) at 510pm during the recovery after the initial ESD from FRALL 0417.
10	The FT405 PV reading is very slow to change due to the fresh air blower taking a long time to get to speed. This is causing wild fluctuations in air flow which is causing repeated ESD's during step changes.
11	After trip to HSBY due to fuel flow deviation, the plant ESD due to low/low air blower discharge pressure(PALL401). This was caused by the air blower fluctuating wildly due to the drastic change in setpoint.
12	ESD- when recovering plant from low/low WTS storage tank level ESD- due to recycle blower failure (UA_406_F) because of the VFD failing to reset.
13	Contractor work on the site has caused damage to the ADG piping and the second stage blower that required taking the plant to HSBY. After discussion with SCS and Alliance Power, the second stage blower will have to be replaced.
14	0835: Trip to HSBY due to PALL_1001, digester compressor low/low suction pressure, alarm. Sanitation department taking ADG to start the boilers.
15	0835: Trip to HSBY due to PALL_1001, digester compressor low/low suction pressure, alarm. Sanitation department taking ADG to start the boilers.
16	Unit taken to HSBY at customer request to work on exhaust to HRU piping
17	Leak was found on customer Gas Skid. Plant was brought to hotstandby until leak could be repaired
18	ESD caused by low/low storage tank level that caused a booster pump low discharge pressure alarm. Operator failed to removed the WTSALARM override after completing maintenance on the water system. This prevented receiving any pages to inform the monitor
19	Customers EDG testing failed resulting in a loss of the grid therefore the plants ESDed.
20	ESD due to customer equipment loss of fuel supply
21	Digester Gas Compressor Skid, tripped on low suction pressure causing NG to be supplied. Plant has not been optimized for NG. Contacted SCS's Adam Pennell, Benny Benson, and Alliance's Brian Mareau. Emaied FCE's Customer Service Rep.
22	Digester Gas Compressor Skid, tripped on low suction pressure causing NG to be supplied. Plant has not been optimized for NG. Contacted SCS's Adam Pennell, Benny Benson, and Alliance's Brian Mareau. Emaied FCE's Customer Service Rep.
23	During Grid Independent event. Plant was resyned to auto connect to the Grid and ramp up. Full time of timer had not elasped. Tried to Initate a load ramp via button load rated and load reducted. Niether was acivtated. Hit grid connect plant ESD.
24	Plant Island mode due to Grid disturbance. After 90min timer reconnected to Grid and shortly after connection another disturbance forced back to Island mode. Visited site to verify BOP and customer conditions ok before next load ramp
25	After unit tripped to islanded HSBY at 950pm, preignition occurred. Operator took actions to extinguish preignition and caused a plant ESD due to FDAHH217(H/H fuel flow deviation) at 1020pm. Plant was recovered without incident.
26	Trip to HSBY when inverter tripped due to a failed drive circuit card. Beside "PCU tripped" , an "inverter_ gat_fault inverter fault #9" was displayed on alarm screen. Drive card was removed from U27 and installed in order to resume power operation.
27	U25 was taken to HSBY at 0710 the morning of 4/5/05 for EDG testing by the sanitation department. Sanitation had problems with the EDG so we stayed in HSBY until 1730 that evening
28	Tripped to HSBY at 8am in order to load versapro project version V155 and cimplicity project version M043. The versapro project contained ECN1811.
29	Plant ESD'd on FDAHH - 231 following a Trip to HSBY. Following a trip to HSBY FV-231 remains at full load value and begins to slowly move toward HSBY CV after approx one min plant ESD's on FDAHH-231.
30	Plant ESD due to FDAHH0231, high/high water deviation from SP. This has happened every time the plant trips from load to HSBY and shift to NG.
31	When plant is tripped to HSBY for any reason plant will subsequently ESD on FDAHH-231. After trip to hsby plant remains in HSBY for approx 1 min after which an ESD will occur if no operator action is taken.
32	Load new hardware configuration for PLC. Plant ESD is involved for this process
33	verified when customer fuel vlave is in the natural gas position that plant trips to hotstandby
34	Plant was in HSBY with FV-217 CV at approximately 60 percent due to loss of NG from SCS Skid manually ESD'd plant
35	Plant was in HSBY with FV-217 CV at approximately 60 percent due to loss of NG from SCS Skid manually ESD'd plant
36	Plant was in HSBY with FV-217 CV at approximately 60 percent due to loss of NG from SCS Skid manually ESD'd plant
37	Plant was in HSBY with FV-217 CV at approximately 60 percent due to loss of NG from SCS Skid manually ESD'd plant
38	SCS low suction press trip resutled in trip to HSBY following this water flow deviations ESD'd the plant
39	Unit 25 ESD'd when SCS Digester gas skid tripped. Cause of trip was determined to be insufficient time delay on power failure trip causing spurious trip of skid. Unit tripped to HSBY transient resulted in ESD due to High water flow deviation.
40	Ramping both unit 25 and 27 together to 250kw. Plant tripped to hot standby due to loss of fuel.
41	ESD due to customer loss of grid for Power testing
42	

ID #	Comments
1	Recovering plant, will update upon power ramp.
2	E&C found a problem in the versapro logic. Problem repaired locally and a new project loaded to permanetley fix the problem.
3	
4	A check of all connections was completed, nothing abnormal found. No further incident for the past 7 weeks.
5	The fresh air blower VFD setting for acceleration timew was found to be too slow for response. Time set to 10 secs vice 60 secs.
6	New versapro logic loaded to fix the problem.
7	Held plant down until ADG pressure was available. 10/11/05: Skid repaired. Plant held in HSBY for 12 hours to ensure skid would not trip again. Plant ramped to 190 kW, no problems
8	Plant was at 110kW at time. The maintenance involved was changing out the softener head and the RO membranes. During the softener head changeout, the drain valve was cracked and had to be replaced. This occurred when softener vessel had to be physically r
9	09/07/05: Recycle blower had to be reset locally. Display on VFD was "HW overcurrent". 11/25/05: This turnback will be closed. All information will be transferred over to turnback 1
10	FT405 is taking a very long time to respond to flow changes. When plant transitioned from on load to HSBY. Plant tripped on FRALL-417 air to fuel ratio. PV for 405 is very slow to respond to controller changes. Possible bad transmitter and or log dampenin
11	This is the same thing that occurred on a ESD recovery on 8/20/05. Just as we had to do then, the blower was taken to manual and placed at 30%. It was kept there until all plant conditions were stable. Failure to take blower to manual would have resulted
12	Site visit made to reset VFD. The message displayed on the VFD display was "HW overcurrent". All parameters per FS. 120 and ECN 1869 were checked and they all were correct. Ken Pulliam, 8/25/05: Engineering needs to look into why this VFD is not auto re
13	Plant to remain in HSBY on NG until the second stage blower can be replaced. Replacement expected by next Tuesday. Ken Pulliam, 8/25/05: Repairs completed on 8/17/05, plant ramped to 100 kW
14	Sanitation department put the boilers on service and informed me that I could bring the unit back up on power. (Ken Pulliam) 07/05/05 Turnback closed, no actions required.
15	Sanitation department put the boilers on service and informed me that I could bring the unit back up on power. (Ken Pulliam) 07/05/05 Turnback closed, no actions required.
16	
17	Plant tripped to hot standby and ramped after leak was repaired and soak timer expired
18	Operator error caused this ESD. Plant is recovered and back to power.
19	No action required
20	
21	SCS required to shift back over to NG. Discrete signal in place and verified functional.
22	SCS required to shift back over to NG. Discrete signal in place and verified functional.
23	Throughly evaluate plant prior to taking corrective actions.
24	
25	A new procedure has been written for this event.
26	During the troubleshooting, it was first observed that the faulty card had its LED lights de-energized. The fuse was checked. It was blown. A known good fuse was installed. It too blew out after being installed. At that moment, decision was made to replac
27	
28	"ECN1811 will allow the plant to fast ramp down to the alarm reduced setpoint when the skid compressor suction pressure drops down to 4"". At 2"", it will cause the plant to ramp to HSBY at normal rate." Recovered plant and ramped back up to 190kW load r
29	Tuning performed on FV231 that has corrected the problem. Plant has tripped to IHSBY 3 times without an ESD or trip to HSBY.
30	Tuning performed on FV231 has corrected the issue.
31	In order to prevent an ESD operator must take FV - 231 to approx 18 percent CV within the first minute after a trip.
32	To enable omnimetrix paging. New output module must be identified in hardware config.
33	verified loop is correct. Test was successful
34	Called SCS representative and informed him of problems SCS Restored NG to plant. Recovered plant to HSBY
35	Called SCS representative and informed him of problems SCS Restored NG to plant. Recovered plant to HSBY
36	Called SCS representative and informed him of problems SCS Restored NG to plant. Recovered plant to HSBY
37	Called SCS representative and informed him of problems SCS Restored NG to plant. Recovered plant to HSBY
38	ADG was lost to SCS Skid SCS Skid switched to NG as main fuel unit did not receive signal to switch fuel type. Recovered plant on NG to HSBY holding plant in HSBY until ADG is restored
39	SCS corrected Skid setting. Commenced ramping powerplant to 190 KW
40	after hot standby soak bring plant to 190kw
41	Plant islanded then ESD due to loss of fuel form the fuel skid
42	Plant was intentionally disabled so SCS could modify gas supply piping. Plant was then recovered and heated up to HSBY.

ID #	DateTimeDown	DateTimePower	TBF	PlanCodeStatus	Major_Component	Category	SubCat	Duration
	31-Dec-05							
1	25-Dec-05	25-Dec-05	149	Customer	Controls System (ELEC)	Hardware(Elec)	Breaker	13.2
2	23-Dec-05	24-Dec-05	23	Customer	Controls System (ELEC)	Hardware(Elec)	Breaker	26.5
3	18-Dec-05	18-Dec-05	117	Forced	WATER TREATMENT GROUP	Mechanical	Not Connected	3.5
4	27-Nov-05	30-Nov-05	420	Forced	FUEL PREPARATION GROUP	Electrical	Inoperable	83.7
5	02-Nov-05	02-Nov-05	587	Customer	External Influence	Fuel Gas	External Equipment	10.0
6	09-Oct-05	11-Oct-05	524	Customer	External Influence	Fuel Gas	Supply interruption	39.3
7	09-Oct-05	09-Oct-05	12	Customer	External Influence	Fuel Gas	External Equipment	7.0
8	04-Oct-05	09-Oct-05	0	Forced	Controls System (I&C)	Electrical	Grounded/Shorted	112.8
9	03-Oct-05	03-Oct-05	20	Customer	External Influence	Customer Equipment	Construction	6.7
10	07-Sep-05	07-Sep-05	611	Customer	External Influence	Grid	Grid Disturbance	10.3
11	31-Aug-05	31-Aug-05	161	Customer	External Influence	Fuel Gas	Pressure	2.0
12	27-Aug-05	27-Aug-05	88	Customer	External Influence	Fuel Gas	Pressure	3.7
13	13-Jul-05	17-Aug-05	242	Customer	External Influence	Customer Equipment	N/A	846.2
14	28-Jun-05	28-Jun-05	356	Customer	External Influence	Customer Equipment	N/A	1.8
15	28-Jun-05	28-Jun-05	2	Customer	External Influence	Customer Equipment	N/A	2.0
16	23-Jun-05	23-Jun-05	123	Forced	Module	Module Instrumentation system	Waiting Module Group Review	0.2
17	23-Jun-05	23-Jun-05	4	Forced	Module	Module Instrumentation system	Waiting Module Group Review	0.3
18	22-Jun-05	22-Jun-05	5	Forced	Module	Module Instrumentation system	Waiting Module Group Review	0.3
19	22-Jun-05	22-Jun-05	0	Forced	Module	Module Instrumentation system	Waiting Module Group Review	1.7
20	22-Jun-05	22-Jun-05	1	Forced	Module	Module Instrumentation system	Waiting Module Group Review	0.3
21	22-Jun-05	22-Jun-05	0	Forced	Module	Module Instrumentation system	Waiting Module Group Review	12.2
22	17-Jun-05	17-Jun-05	113	Customer	External Influence	Customer Equipment	n/a	2.0
23	16-Jun-05	16-Jun-05	12	Customer	External Influence	Grid	Grid Disturbance	6.0
24	01-Jun-05	01-Jun-05	354	Customer	External Influence	Customer Equipment	N/A	11.7
25	04-May-05	04-May-05	662	Customer	External Influence	Customer Equipment	Gas Compressor	14.5
26	30-Apr-05	01-May-05	64	Customer	External Influence	Fuel Gas	External Equipment	21.8
27	29-Apr-05	29-Apr-05	18	Customer	External Influence	Fuel Gas	External Equipment	3.0
28	28-Apr-05	28-Apr-05	41	Customer	External Influence	Customer Equipment	Gas Compressor	0.2
29	24-Apr-05	24-Apr-05	80	Forced	Controls System (ELEC)	Software(Elec)	Drives	14.0
30	04-Apr-05	22-Apr-05	40	Forced	FUEL PREPARATION GROUP	Mechanical	Leaks Externally	423.3
31	31-Mar-05	31-Mar-05	105	Customer	External Influence	Fuel Gas	Not Connected	1.7
32	29-Mar-05	29-Mar-05	41	Forced	Fuel Preparation Group	Instrumentation	Not Connected	1.7
33	25-Mar-05	25-Mar-05	96	Customer	External Influence	Fuel Gas	Pressure	2.7
34	22-Mar-05	22-Mar-05	70	Customer	External Influence	Grid	Grid Disturbance	3.8
35	17-Mar-05	17-Mar-05	115	Planned	Controls System (I&C)	Software (I&C)	Versapro	2.2
36	28-Feb-05	02-Mar-05	359	Customer	Controls System (I&C)	Software (I&C)	Versapro	40.8
37	27-Feb-05	27-Feb-05	26	Customer	Controls System (I&C)	Software (I&C)	Versapro	0.8
38	26-Feb-05	27-Feb-05	0	Customer	Controls System (I&C)	Software (I&C)	Versapro	27.5
39	18-Feb-05	18-Feb-05	196	Customer	Controls System (I&C)	Software (I&C)	Versapro	2.2
40	16-Feb-05	16-Feb-05	42	Customer	Controls System (I&C)	Software (I&C)	Versapro	0.8
41	14-Feb-05	16-Feb-05	2	Customer	External Influence	Fuel Gas	Supply interruption	47.2
42	14-Feb-05	14-Feb-05	10	Customer	External Influence	Fuel Gas	Supply interruption	0.5
43	13-Feb-05	14-Feb-05	1	Customer	External Influence	Fuel Gas	Supply interruption	2.2
44	08-Feb-05	08-Feb-05	130	Customer	External Influence	Fuel Gas	Pressure Deviation	1.5
45	03-Feb-05	03-Feb-05	111	Customer	External Influence	Fuel Gas	Pressure	4.5
46	01-Feb-05	01-Feb-05	52	Customer	External Influence	Series of Test	Logic	4.7
47	25-Jan-05	26-Jan-05	141	Customer	External Influence	Fuel Gas	External Equipment	24.5
48	17-Jan-05	17-Jan-05	186	Customer	External Influence	Human Performance Error	Vendor Techician Error	4.8
49	14-Jan-05	14-Jan-05	60	Customer	External Influence	Fuel Gas	External Equipment	4.2
50	10-Jan-05	13-Jan-05	20	Customer	External Influence	Fuel Gas	Pressure	87.4
51	08-Jan-05	10-Jan-05	0	Customer	External Influence	Fuel Gas	Composition	36.2
52	04-Jan-05	04-Jan-05	98	Forced	FRESH AIR GROUP	Human Performance Error	FCE technician error	2.3
53	03-Jan-05	03-Jan-05	25	Forced	Power Conversion Group	Calibration	Power Conditioning Unit	3.5
54	28-Dec-04	29-Dec-04	123	Forced	Module	Performance	Voltage Deviations	14.3
55	28-Dec-04	28-Dec-04	16	Customer	External Influence	Grid	Grid Disturbance	1.5
		20-Dec-04	191				Total	2003.7
	total time between failure		7044 hrs					

		Number of events
Mean Time Between Failure	127 hrs	
Total Scheduled Outages	2.2 hrs	1
Mean Time of Scheduled Outages	2.2 hrs	
Total Unscheduled Outages - Fuel Cell	674.1 hrs	15
Mean Time of Unscheduled Outages - Fuel C	44.9 hrs	
Total Unscheduled Outages - Customer	1327.4 hrs	37
Mean Time of Unscheduled Outages - Custo	35.9 hrs	

total outage	2003.7
total hours	9048

ID #	Issue
1	Plant ESDd on a grid disturbance. Power was not available for several hours, UPS lost power. Technician was dispatched to shut TB.
2	Plant ESDd on a grid disturbance. Power was not available for several hours, UPS lost power. Technician was dispatched to shut TB.
3	Intentionally tripped the plant to HSBY to conserve water. A 12mm plug on the RO pump discharge tee had been ejected off. Site visit conducted and plug was re-installed. System restored.
4	Plant had to be ESDed due to the loss of fuel.
5	Disabled the plant for SCS to perform maintenance on the pre-treatment skid.
6	ESD due to EALL_0369, low/low avg stack voltage due to loss of fuel flow from customer
7	The ADG Skid has a refrigerant leak which causes the chiller to run high and trip the unit. The plant is on NG. SCS estimate repairs to be completed on 11 Oct. 2005.
8	At 0714 Plant Transitioned to HSBY. Alarm in was PCU Tripped, Trip fault from PLC, and Global Fault. At 0752 AC contactor CR2 Fault and CR1 Contactor Faults are in. At first thought to be a pancake relay. Dispatched to find relays are good. T/S in p
9	ADG Skid chiller failure, SCS Rep unable to find cause. Troubleshooting for the day and later was able to correct fault
10	ESD at ~830am due to TB opening. The plant had been manually transitioned to grid independent mode at 7am.
11	Plant tripped to HSBYdue to SCS tech tripping gas skid
12	Plant tripped to HSBYdue to SCS tech tripping gas skid
13	Contractor on site caused damage to the ADG piping and the second stage blower. Piping leak repaired, blower will have to be replaced.
14	0835 plant tripped to HSBY due to PALL_1001, digester compressor low/low suction pressure alarm. Sanitation department was starting the boilers and took most of the ADG fuel.
15	0835 plant tripped to HSBY due to PALL_1001, digester compressor low/low suction pressure alarm. Sanitation department was starting the boilers and took most of the ADG fuel.
16	TD368 Load Temp Diff Alarmin and holding ramp.TE368f was at 1294.
17	TD368 Load Temp Diff Alarmin and holding ramp.TE368f was at 1294.
18	TD368 Load Temp Diff Alarmin and holding ramp.TE368f was at 1294.
19	TD368 Load Temp Diff Alarmin and holding ramp.TE368f was at 1294.
20	TD368 Load Temp Diff Alarmin and holding ramp.TE368f was at 1294.
21	TD368 Load Temp Diff Alarmin and holding ramp.TE368f was at 1294.
22	Customer Gas skid was found to have fuel leak
23	Grid distrubance
24	Performed a manual ESD due to loss of fuel from the treatment skid. SCS restarted the skid on the first loss of power but failed to restart it on the second loss of power. The unit ran off the fuel in the carbon beds until all fuel was used up.
25	ESD due to customer gas compressor shutdown
26	Digester Gas Compressor Skid tripped on low suction pressure causing NG to be supplied. Plant has not been optimized for NG. Left message with SCS Adam Pennell, Benny Benson, and Alliance Pwr. Brian M. cell. Emailed FCE's customer serice rep.
27	Digester Gas Compressor Skid tripped on low suction pressure causing NG to be supplied. Plant has not been optimized for NG. Left message with SCS Adam Pennell, Benny Benson, and Alliance Pwr. Brian M. cell. Emailed FCE's customer serice rep.
28	ESD due to customer gas compressor shutdown
29	Plant Islanded due to Grid Disturbance. After timer expired connected to grid. Plant ESD due to TB tripped open or failed to close. Visited site and verified no issues prevented TB from closing. Manually closed TB and commenced heat-up
30	After observing steam plumes coming from insulation around the sumitomo anda high AT232 readings, plant was cooled down and investigation performed Sumitomo HX leaking on gas inlet side. Replacement ordered and set for install on week of 4/18.
31	Loss of digester lead to PAL_1001, DG compressor low suction pressure. The plant tripped to HSBY 17 secs later due to IDAHL-0347, DC current actual vs stpt deviation alarm
32	The plant tripped to HSBY on IDAHL_0347 when an alarm reduced kW alarm was received. This is the second occurrence of this.
33	Due to a reduction in digester production, the plant ramped to the alarm kW setpoint. 25 secs later the plant tripped to HSBY due to IDAH_0347, current actual vs setpoint deviation. Plant remained in HSBY till 90 min soak was completed and then ramped.
34	0924: Unit tripped to IHSBY due to a grid distrubance.
35	Tripped plant to HSBY at 110pm in order to install Versapro project V134 and cimplicity project M031. Versapro project V134 contained ECN1811.
36	Shortly after trip to HSBY plant ESD's on FDAHH-231. When a trip to HSBY occurs FV-231 remains at its full load CV and slowly begins to move toward HSBY CV after approx 1 min plant will ESD on FDAHH-231.
37	Shortly after trip to HSBY plant ESD's on FDAHH-231. When a trip to HSBY occurs FV-231 remains at its full load CV and slowly begins to move toward HSBY CV after approx 1 min plant will ESD on FDAHH-231.
38	Plant ESD due to FDAHH 0231, high/high water flow deviation from setpoint. This is a known problem, the plant ESDs everytime we trip to HSBY due to this.
39	Verifiy that when customer natural gas blending valveis in the natural gas postion. The plant trips to hotstandby
40	Verifiy that when customer natural gas blending valveis in the natural gas postion. The plant trips to hotstandby
41	Plant was in HSBY with FV-217 CV at approximately 60 percent due to loss of NG from SCS Skid manually ESD'd plant
42	Plant was in HSBY with FV-217 CV at approximately 60 percent due to loss of NG from SCS Skid manually ESD'd plant
43	SCS skid suction press low trip caused plant to trip to HSBY resulting water flow deviations tripped plant.
44	Plant ESD'd due to SCS fuel skid trip. SCS Skid tripped due to insufficient time delay on loss of power trip in logic this caused a spurious trip of the skid. Skid trip resulted in trip to HSBY on fuel flow deviation, ESD due to FDAHH231
45	Ramping unit 25 and 27 to gether to 250kw. Plnat Esd due to loss of fuel
46	Ramped to 175kw after site testing was completed
47	Plant intentionally disabled so SCS could modify gas supply piping.
48	Trip to HSBY due to fuel flow deviation caused by SCS technician operating valves on pretreatment skid that momentarily interrupted fuel flow. Vendor did not contact FCE prior to operating valves.
49	01/14/05: Ramped plant to HSBY to support SCS in their installation of the pretreatment skid natural gas valve.
50	Trip to HSBY on 01/10/05 on fuel flow deviation caused by loss of one of the site digesters. The digester has some faulty mechanical parts that need to be replaced. This is the second time in three days this has occured.
51	On 01/06/05, an extremely insufficient air flow was observed, causing a high diff temp across stack. Root cause appears to be a reduction in CH4 content of ADG gas, which caused a chain of events leading to the reduced air flow. Plant fast ramped down.
52	Experienced 2 ESD's during troubleshooting of TV305B due to 24V to ground. Wiring problem that was causing TV305B to be inoperable was found and corrected.
53	Placed overrides on plant in attempt to prevent plant from transitioning from 175kW to HSBY when FCI Calibrator connected. Placed control vavles in manual. Connected Calibrator for data collectio Plant transitioned to HSBY.
54	
55	

ID #	Comments
1	Plant heating up, will update when power ramp commences.
2	Plant heating up, will update when power ramp commences.
3	The system had been operating with RO pump discharge pressure at or near 200# for two weeks. This was in order to provide enough EDI inlet flow because of severely clogged RO membranes. 200# is the max pressure allowed. The increasingly frequent run time
4	Relay RY1 failed causing XV205A to go shut.
5	
6	SCS personnel at site changed the valve lineup, resulting in isolating the fuel to U27
7	10/11/05: ADG skid repaired. Left plant in HSBY for 12 hours to ensure the skid would stay operating. Ramped plant to 190 kW, no problems.
8	Problem found to be the KVAR mode was enabled, this prevented the unit from ramping. Disabled KVAR mode and plant was able to ramp. This is a logic problem that E&C wil have to provide a fix for. No versapro logic loaded to fix the problem with KVAR m
9	Held plant down until ADG pressure was available.
10	Have found no reason on why this has happened but have been unable to get it to repeat.
11	SCS technician was adjusting gas skid pressure and tripped the compressor. This casued the fuel cell to trip to HSBY.
12	SCS technician was adjusting gas skid pressure and tripped the compressor. This casued the fuel cell to trip to HSBY.
13	Plant to remain in HSBY on NG until the second stage blower can be replaced. Expect replacement by next Tuesday. Ken Pulliam, 8/25/05: Repairs completed on 8/17/05 and plant ramped up.
14	Sanitation department started boilers and reduced their ADG consumption so the fuel cells could come back on line. (Ken Pulliam) 07/05/05 Turnback closed, no action required.
15	Sanitation department started boilers and reduced their ADG consumption so the fuel cells could come back on line. (Ken Pulliam) 07/05/05 Turnback closed, no action required.
16	Called Ramki for recommandation. He advised to raiseHigh Load Alarm SP,TD368 from 210 to 300.Began ramping unit. TD0368F has been removed from the calculation locally and the master has been updated.
17	Called Ramki for recommandation. He advised to raiseHigh Load Alarm SP,TD368 from 210 to 300.Began ramping unit. TD0368F has been removed from the calculation locally and the master has been updated.
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21	Called Ramki for recommandation. He advised to raiseHigh Load Alarm SP,TD368 from 210 to 300.Began ramping unit. TD0368F has been removed from the calculation locally and the master has been updated.
22	Plant tripped to hot standby until fuel leak repaired. Plant then ramped in power, after soak timer expired
23	Plant went to Island mode after grid disturbance. Pre-ignition existed. Had to ESD plant to extinguish.Ramped ot hot-standby. Began load ramp after HSBY soak.
24	Contacted SCS and they restarted the skid. Once skid was restarted, the unit was recovered and commenced a heatup.
25	0500 go to HSBY in preparation for ADG testing Notified Santa Barbara Operations prior 0830 Alternate fuel source alarms came in 0930 Plant ESD due to loss of fuel when gas compressor tripped off Attempted to heatup plant, found recycle blower VFD tri
26	Awaiting SCS to shift NG diverter valve back over to ADG. Discrete signal in place and vierfied functional.
27	Awaiting SCS to shift NG diverter valve back over to ADG. Discrete signal in place and vierfied functional.
28	0500 go to HSBY in preparation for ADG testing Notified Santa Barbara Operations prior 0830 Alternate fuel source alarms came in 0930 Plant ESD due to loss of fuel when gas compressor tripped off Attempted to heatup plant, found recycle blower VFD tri
29	
30	Full report on old HX was made to Danbury. There was no distortion or discoloration. There were only two small leaks on plating of gas inlet side. Sumitomo HX was replaced on 4/15 and 4/16 by Don Bell and Jon Evans.
31	
32	
33	
34	Preignition occurring, this will require reconnecting to the grid and then tripping the unit to HSBY. 1000: Tripped plant to HSBY. After working on extingishing preignition for 1.5 hours, I disabled the plant to put it out. 1125: Plant disabled. 113
35	"ECN1811 will cause the plant to fast ramp down to alarm reduced setpoint when skid compressor suction pressure drops down to 4"",and ramp to HSBY at the normal rate when suction pressure reaches 2""." Filled salt tank.
36	Tuning performed on FV231 that has corrected the problem.
37	Tuning performed on FV231 that has corrected the problem.
38	Tuning performed on FV231 that has corrected the issue.
39	Plant did not trip to hotstandby. Implemented field change in versapro to transition from step 8 to step 7 on input received form customer.
40	Plant did not trip to hotstandby. Implemented field change in versapro to transition from step 8 to step 7 on input received form customer.
41	Called SCS representative and informed him of problems SCS Restored NG to plant. Recovered plant to HSBY
42	Called SCS representative and informed him of problems SCS Restored NG to plant. Recovered plant to HSBY
43	ADG was lost to SCS Skid SCS Skid switched to NG as main fuel unit did not receive signal to switch fuel type. Recovered plant on NG to HSBY holding plant in HSBY until ADG is restored.
44	SCS corrected digester gas skid power failure time delay
45	recovered plant and bring back to 190kw
46	monitor plant operation and continue fuel usage testing
47	Recovered and commenced heating up plant once modifications were completed. Plant is holding at 1103F due to high 368K diff temp alarm.
48	Recovered plant. Spoke to vendor and warned him about doing it again.
49	Unlike unit 25, when override was removed on XS_1001, setpoints remained unchanged.Wiring verified correct. Logic is always seeing the contact closed. Contact should be opened on loss of ADG. Override placed back on XS_1001 until this issue is resolved.
50	Conducted investigation of site equipment.
51	
52	Recovered plant. Made entry in daily report.
53	Alarms range limits exceeded FC_0417,FT-0217, HSB Soak and then PCU tripped. While in HSBY pre-ignition occurred. Proceeded to extinguish pre-ignition. Each attempt failed. Tripped plant and choked off fuel to the skid to prevent reoccurance while hea
54	0430 Unit ESD low low voltage.
55	0415 Unit Trasitioned to HSBY, possibly ISLAND HSBY due to possible Grid Disturbance.